Title: Advancing Materials Characterization through Fourth-Generation Synchrotron Sources: In Situ and Operando X-ray Powder Diffraction Studies

Abstract

X-ray crystallography has been a cornerstone of scientific progress for over a century, enabling transformative discoveries across physics, chemistry, biology, and materials science. However, the advent of synchrotron radiation in the 1970s and 80s revolutionized the field by providing electromagnetic radiation of unprecedented intensity. The evolution through second and third-generation sources enabled breakthroughs in high-resolution powder diffraction and macromolecular crystallography. Today, we are witnessing a new era with the emergence of 4th-generation synchrotrons. These facilities, such as the Sirius light source at LNLS-CNPEM in Campinas, Brazil, offer extraordinary brilliance and spatial coherence, opening new frontiers for highly advanced experiments in fields such as sustainable energy, human health, and cultural heritage.

This talk will explore the unique capabilities of these next-generation facilities and their impact on applied crystallography. To illustrate these capabilities, we will discuss recent research on solid oxide fuel cells (SOFCs). Specifically, we present an in situ synchrotron X-ray powder diffraction (XPD) study of the structural and redox behavior of new materials of double perovskite crystal structure for symmetric SOFCs. By employing temperature-dependent synchrotron XPD under controlled oxidizing and reducing atmospheres, we monitored their stability and correlated structural evolution with electrochemical performance. These results, complemented by X-ray absorption spectroscopy (XAS), demonstrate how advanced synchrotron-based methodologies are essential for designing the next generation of materials for sustainable energy applications.